

REMARKS

Reconsideration of this application, as amended, is respectfully requested.

In the Office Action, the Examiner rejects claims 1-7. Claims 8-22 were withdrawn in a response to the restriction requirement of March 12, 2004. Claims 1-2 and 5-7 are rejected under 35 U.S.C. §102(a) as being allegedly anticipated by U.S. Patent No. 6,720,654 to Stumborg et al. (hereinafter “Stumborg”). Claims 3-4 are rejected under 35 U.S.C. §103(a) as being allegedly unpatentable over Stumborg. In response, independent claim 1 has been amended to clarify its distinguishing features.

Specifically, independent claim 1 has been amended to include the limitations of independent claim 2. Further, claims 3 and 5 have been amended to correct the spelling of “aluminum”. Lastly, dependent claims 23 and 24 have been added, for which support is found throughout the specification; specifically, on pages 27 and 34. Therefore, Applicants respectfully submit that no new matter has been added by way of the amendment to the claims and by the addition of the new claims.

As seen in Fig. 4, independent claim 1 recites a semiconductor apparatus comprising an under layer formed above a substrate 1, a first insulating layer (2 and 3) formed on the under layer, and a first conductive portion 7a formed in a first concave portion 3a which passes through the first insulating layer to the under layer. The first conductive portion 7a includes a first barrier metal layer 4 formed on a side wall and a bottom surface of the first concave portion 3a, and a first metal portion formed on the first barrier metal layer 4 such that the rest of the first concave portion 3a is filled with the first metal portion. The first metal portion includes a first alloy comprising copper and aluminum.

Further, claim 1, as amended, specifically recites that the percentage of aluminum in the first alloy is 0.1 to 10 atm%. Claim 3 recites that the percentage of aluminum in the second alloy is 0.1 to 10 atm%. These specific values are not disclosed or made obvious by the reference of Stumborg.

The Examiner alleges that Stumborg discloses all the features of independent claim 1. Stumborg, in Fig. 8, teaches a substrate layer 46 with an insulating layer 48 formed on top of the substrate layer. A side wall barrier 49 and diffusion barrier layer 47 forms a concave portion in the insulating layer 48, with a plug 45 formed of a metal such as copper that conducts current between layer 46 and a layer that is separated from substrate layer 46 by insulating layer 48. Further, Stumborg, in Col. 13, lines 29-31, teaches that the conductive layer can comprise a Cu-Al alloy.

The present specification, on pages 23-30, teaches that the Al content in the alloy, which is related to the thickness of the Al or the material including aluminum formed on the copper, and the heat-treatment condition, has an effect on the present invention. As seen in the specification, tests were carried out to set the desirable Al content and the desirable heat-treatment condition.

As for the Al content ratio, when the Al content is too low, the decrease of the diffusion coefficient is not enough. In this case, the sufficient restraint effect of the transportation phenomenon cannot be obtained. To the contrary, when the Al content is too high, the resistance is substantially equal to that of Al. In this case, the merit of using the Cu interconnection will disappear.

Fig. 7 shows a graph showing the relation among the Al content, the yield and the heat-treatment time. The horizontal axis shows the samples which are different from each other in the

Al content. The vertical axis shows the yield for fair quality products. Each bar corresponds to the heat-treatment time as shown in the box drawn in the right side of the graph. The film thickness of Cu is 700 nm. As shown in Fig. 7, there is no effect to the yield when alloying Cu with Al which is equal to or less than 20 nm of Al film thickness. On the other hand, there is the effect to improve the yield when alloying Cu with Al which is equal to or more than 40 nm of Al film thickness. In this case, the containing percentage of Al in the Cu with 40 nm Al (Cu-Al (Al:40nm) in Fig. 7) was 0.1 atm%. Therefore, the containing percentage of Al in the alloy should be equal to or more than 0.1 atm%.

Also, the mechanical strength rises when making Cu alloy but the electric conductivity decreases. Therefore, the Al content must be provided from the viewpoint to suppress the decrease of the electric conductivity of the interconnection material in the latitude and moreover to achieve the mechanical strength which the LSI needs. It was found that the range of 0.1 to 10 atm% was the optimal range of the Al content in the copper aluminum alloy. Thus, independent claim 1 specifically recites that the containing percentage of Al in the first alloy is 0.1 to 10 atm%.

Further, claim 6 recites that where a width of the first conductive portion is equal to or less than 0.18 μm , a depth of the first conductive portion is equal to or greater than 0.3 μm , and a thickness of the first barrier metal layer is equal to or greater than 0.01 μm , such that the first metal portion is formed in the first concave portion. Stumborg fails to disclose these exact values.

Anticipation requires the presence in a single prior art reference, disclosure of each and every element of the claimed invention, arranged as in the claim. Lindeman Maschinenfabrik GMBH v. American Hoist and Derrick Company, 730 F.2d 1452, 1458, 221 U.S.P.Q. 481, 485

(Fed. Cir. 1984). Regarding the 35 U.S.C. §102(a) rejection of claims 1-2 and 5-7, Applicants respectfully submit that Stumborg fails to disclose each and every element of the claims, as clearly shown above. Accordingly, Applicants respectfully request withdrawal of the 35 U.S.C. §102(a) rejection of claims 1-2 and 5-7.

Regarding the 35 U.S.C. §103(a) rejection of claims 3-4, Applicants respectfully submit that unexpected results have been shown in regard to the claimed range of 0.1 to 10 atm%. The law is replete with cases in which the difference between the claimed invention and the prior art is some range or other variable within the claims. These cases have consistently held that in such a situation, the applicant must show that the particular range is critical, generally by showing that the claimed range achieves unexpected results relative to the prior art range. In re Woodruff, 919 F.2d 1575, 1578, 16 U.S.P.Q.2d 1934, 1936 (Fed. Cir. 1990).

This has been clearly demonstrated above, and in the specification, that tests were carried out to set the desirable Al content and the desirable heat-treatment condition. It was found that the mechanical strength rises when making Cu alloy but the electric conductivity decreases, and that the Al content must therefore be provided from the viewpoint to suppress the decrease of the electric conductivity of the interconnection material in the latitude and moreover to achieve the mechanical strength which the LSI needs. It was found that unexpected results, specifically, that the range of 0.1 to 10 atm% suppressed decrease of the electric conductivity but still achieved the mechanical strength required by the LSI, occurred when this testing was performed.

Accordingly, Applicants respectfully request withdrawal of the 35 U.S.C. §103(a) rejection of claims 3-4, and respectfully request allowance of claims 1, 3-7 and 23-24.

In view of the above, it is respectfully submitted that this application is in condition for allowance. Accordingly, it is respectfully requested that this application be allowed and a Notice

of Allowance issued. If the Examiner believes that a telephone conference with Applicants' attorney would be advantageous to the disposition of this case, the Examiner is requested to telephone the undersigned.

Respectfully submitted,



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